# UNRAVELLING SEMI-COMPENSATORY CHOICE: DATA COLLECTION BASED ON TWO-STAGE CHOICE PROTOCOLS

*KAPLAN Sigal, Faculty of Civil and Environmental Engineering, Technion*
*BEKHOR Shlomo, Faculty of Civil and Environmental Engineering, Technion*
*SHIFTAN Yoram, Faculty of Civil and Environmental Engineering, Technion*

## ABSTRACT

The present study proposes a two-stage procedure to collect data about semi-compensatory choice processes in a digital economy environment. At the first stage, individuals form their viable choice set by specifying a set of tolerated criteria thresholds. At the second stage, individuals choose their most preferred alternative. The digital economy environment allows seamless tracking of the two-stage choice protocols without interfering with the natural choice process and without introducing problems related to comprehension bias, narrative inconsistency and misinterpretation of the choice protocols. The procedure is accompanied by a questionnaire collecting personal information that can be associated to threshold selection. The procedure is applied to off-campus apartment rental choices by students in order to demonstrate its capability to retrieve tolerated criteria thresholds and choice outcomes from cross-sectional data in a choice situation entailing many alternatives and multiple criteria. Results show the importance of elimination-based choice set formation, the distribution of threshold selection across the population, the characteristics of the considered choice sets, and the linkage between the choice set formation and the choice.

*Keywords: Two-stage elicitation, thresholds, direct elicitation, decision protocols*

## INTRODUCTION

The conceptual framework of semi-compensatory models, derived from the studies of Manski (1977) and Swait and Ben-Akiva (1987), includes a probabilistic two-stage choice process, consisting of an elimination-based choice set formation upon satisfying random constraints, followed by a utility-maximization based choice (Ben-Akiva And Boccara, 1995). Curiously, although this assumption constitutes a consensus in the literature of semi-compensatory models, there are no attempts to collect data regarding semi-compensatory choice processes for the purpose of model estimation. Rather, state-of-the-art semi-compensatory models are developed and estimated solely on the basis of choice outcomes (Ben-Akiva and

Boccara, 1995; Morikawa, 1995; Swait, 2001; Başar and Bhat, 2004; Cantillo and Ortúzar, 2005; Cantillo et al., 2006, Zheng and Guo, 2008; Castro et al., 2009).

Possible reasons for the sole reliance of current semi-compensatory models on choice outcomes are the wide agreement of the aforementioned studies with Tversky's (1972) assumption that the elimination-based choice set formation process is covert, and the difficulty to impute choice sets on the basis of observational data from traditional natural experiments (Ben-Akiva and Boccara, 1995). Although data collection with respect to choice set formation is not addressed in the literature related to semi-compensatory models, the issue of capturing thresholds as a premise for choice set formation is widely discussed in psychophysics in order to measure psychological reactions to physical stimuli. Further, threshold elicitation has been widely discussed in the marketing literature with respect to the price acceptability range. Three prevailing methods for threshold elicitation are direct surveys, conjoint-based analysis and market data.

Direct surveys consist of interviewing respondents about the upper and lower limits of their acceptable range of values for a specified product. Alternative formats are own-category procedure derived from the fundamentals of psychophysical experiments (Monroe, 1971), and explicit open-ended questions (e.g., Lichtenstein et al., 1988; Wang et al., 2007). Although widely applied, direct surveys are criticized for producing incentive compatibility bias and strategic response bias (Wang et al., 2007) when utilised to elicit the acceptable price range before a decision is made. Post-decision recall of thresholds after an actual choice should be bias free. However, it produces inaccurate or partial results due to memory retrieval difficulties (Gensch and Svestka, 1979). Another limitation of direct surveys is their referral to a single pre-specified alternative. Encompassing the entire range of alternatives by using detailed descriptions is burdensome and expensive. Using instead general descriptions leads to inconsistent elicitation since subjects imagine different reference alternatives.

Conjoint analysis (e.g., Kohli and Mahajan, 1991; Jedidi and Zhang, 2002) serves to infer thresholds for multi-attribute products from preference or choice data. These methods avoid excessive attention to the price acceptability range and thus are considered as incentive neutral (Wang et al., 2007). A limitation of conjoint analysis and choice-based experiments consists in their attempt to infer an essentially non-compensatory concept (thresholds) from compensatory behaviour. In addition, these methods assume that individuals are fully informed regarding their choice sets before revealing their preference structure. However, in realistic choice situations this assumption does not hold (Shocker et al., 1991).

Market data analysis is conducted by using panel data or store scanner data. Although market data methods have the advantage of relying on revealed preference data, their disadvantages are high operating costs, dependency on historical price fluctuations and inability to encompass new products (Breidert et al., 2006). In addition, current market data collection methods rely solely on choice data, and while recurrent choices under different market conditions yield some information regarding thresholds, it is impossible to retrieve such information from single choice events.

A major disadvantage of all the aforementioned methods is that they focus only on threshold elicitation, rather than on the entire semi-compensatory process. Analyzing verbal decision protocols recorded during a choice task is potentially a powerful method for unravelling the entire semi-compensatory choice process. This method, originally employed by Payne (1976), involves recording actions and intentions of individuals by asking them to "think aloud" while performing a choice task. The advantage of this method is twofold. First, the method can reveal both non-compensatory threshold selection and compensatory choice during a choice task. Second, the method is bias free when the choice protocols are recorded for actual transactions. Nevertheless, traditional methods of recording choice protocols (i.e., writing transcripts and audio-video) are subject to two severe limitations that impede their wide application. First, recording verbal choice protocols necessitates a laboratory setting, which in turn imposes restrictions on testing behaviour in realistic choice situations. Second, verbal choice protocols involve problems of respondents' burden, narrative heterogeneity and difficulty of individuals to articulate their thoughts in a structured manner.

The present study proposes a novel two-stage elicitation procedure to collect data about the entire semi-compensatory choice process in a digital economy environment. The procedure enables to retrieve tolerated criteria thresholds and choice outcomes from cross-sectional data in complex choice situations entailing many alternatives and multiple criteria. The choice context of the procedure and several design elements enable to avoid incentive compatibility bias and strategic response bias at the criteria specification stage. The web-based environment allows the implementation of the procedure for collecting either revealed preference (RP) or stated preference (SP) data. The computer-based recording of the two-stage choice protocols avoids problems of respondents' burden, narrative inconsistency and misinterpretation of the choice protocols. The procedure is accompanied by a questionnaire collecting personal information that can be associated to the selected thresholds and choice outcomes.

The proposed two-stage elicitation procedure is applied to a stated preference choice experiment of off-campus rental apartment choices by students, as an example of a complex choice situation involving a large number of alternatives characterised by many attributes. The remainder of the paper is organized as follows. The next section presents the proposed two-stage elicitation procedure. The third section illustrates the application of the proposed procedure within the empirical context. The fourth section focuses on the analysis of the collected data. Last, the fifth section draws conclusions and recommends further research.

## TWO-STAGE ELICITATION PROCEDURE

The current study proposes an innovative two-stage procedure for the combined elicitation of thresholds and choice outcomes. The proposed method relies on evidence from decision making studies showing that: (i) when faced with many alternatives, individuals use a sequence of an attribute-based heuristic and an alternative-based strategy (Payne et al., 1993); (ii) intrinsic constraints and attitudes can be measured similarly to the measurement of responses to physical stimuli in psychophysics (Monroe, 1971); (iii) information regarding

individual preferences can be inferred from choice outcomes. The following sections describe the proposed elicitation procedure, its advantages and limitations, and the prevention of possible biases related to the application of the method to collect stated preferences.

## Procedure overview

The two-stage procedure is illustrated in Figure 1. At the first stage, individuals overtly specify their tolerated criteria thresholds in order to delimit the universal realm of alternatives to a viable choice set. The threshold specification is conducted from a list of fixed criteria threshold values. At the second stage, individuals choose their preferred alternative from their retained choice set. In the event that the procedure does not yield any satisfactory result, individuals either settle for their most preferred alternative among the available ones that satisfy their tolerated thresholds, or update their thresholds, or retreat to a "no choice" option. A questionnaire supplements this procedure by collecting individuals' socio-economic characteristics, attitudes and perceptions in order to associate the threshold selection to individuals' observed heterogeneity.

The data collection method assumes partial information regarding the universal realm of alternatives at the criteria specification stage and full information regarding the profile of alternatives at the choice stage. Specifically, at the criteria specification stage individuals are aware of the general category, for example "rental apartments", delimited by the possible range of criteria values, but they do not possess detailed information regarding the attribute values of all the alternatives in the universal realm. Theoretically, such information could be retrieved by repetitive criteria specification and thorough investigation of the viable choice set. Practically, such a process is unfeasible for a large number of attributes and a large universal realm. Accordingly, the criteria specification depends solely on individuals' intrinsic constraints, preferences and perceptions as well as informal knowledge of the attribute value range included in the universal realm. At the choice stage, individuals are fully informed regarding the exact profiles of the alternatives that satisfy the selected criteria thresholds.

Individual threshold values and chosen alternatives are retrieved for respondents by recording their two-stage choice protocols. As explained in the introduction, the traditional method of recording verbal choice protocols by asking people to "think aloud" necessitates a laboratory setting, is costly and time consuming, and bears problems of individuals having difficulty to articulate their thoughts in a structured manner. Instead, the current study proposes computer aided recording of choice protocols by tracking the series of individuals' typing actions during the criteria specification and choice process in a web-based environment.

The data collection method can be applied either as a SP or a RP survey in actual choice conditions. Under SP survey conditions, a hypothetical choice experiment is designed to simulate real choice conditions in which participants choose among alternatives from a synthetic database. Under RP survey conditions, actual transactions in digital economy are traced.

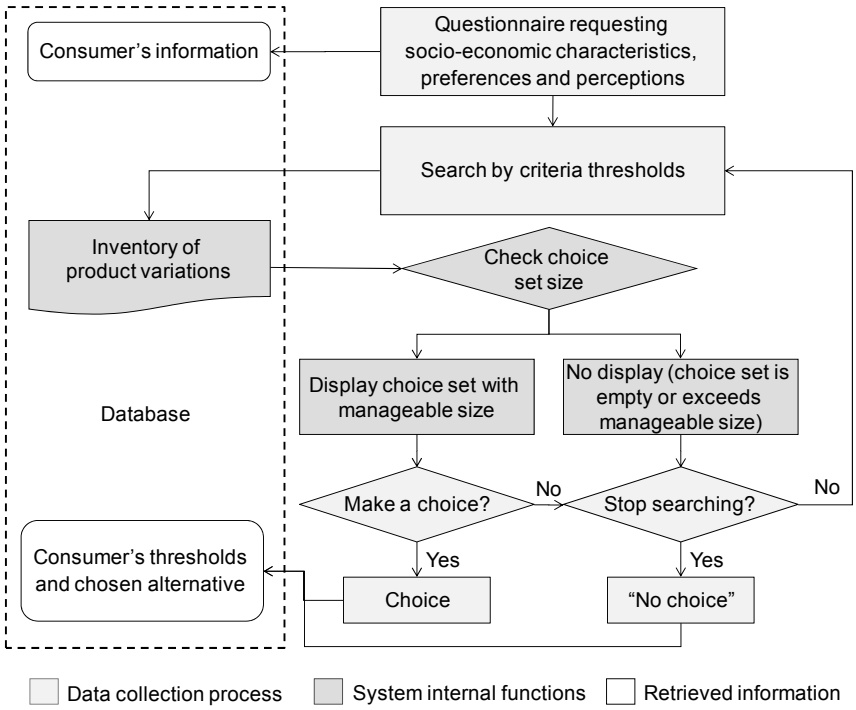


Figure 1 – Proposed two-stage elicitation procedure

## Benefits and limitations of the web-based environment

The benefit of computer-aided tracking of choice protocols is fourfold from the researchers' perspective. First, it helps avoiding the problems of phrasing inconsistency and misinterpretation of verbal choice protocols. Second, it prevents coding mistakes. Third, it does not interfere with the natural choice process, since individuals are unaware that their actions are recorded unless specifically informed. Last, the operational costs associated with a web-based environment in terms of time, human resources and budget are modest when compared to other survey forms such as home interviews and phone surveys. The benefit of the web-based environment is twofold for individuals engaged in the criteria specification and choice procedure. First, respondents' burden for participating in the experiment is minimal, as individuals are able to perform actual or hypothetical transactions as they naturally do in a digital economy environment without being asked to conduct the extra cognitive effort of "thinking aloud". Second, individuals are minimally disturbed in their daily activities due to the schedule and location flexibility provided by the web-based environment.

Although computer aided recording of choice protocols in a web-based environment is highly advantageous, a possible limitation is the necessary condition that respondents are familiar with the Internet media and have accessibility to an Internet connection. However, with the widespread penetration of the Internet media all over the world and among all age groups, this condition seems less and less a limitation. An additional challenge concerns sample reliability. The web-based environment offers less control over sample composition and is at higher risk of fraud than traditional surveys, since it provides a much higher degree of anonymity and location flexibility. However, in order to maintain a high level of sample

reliability, the survey can be designed to control access by asking respondents to identify themselves through individual passwords to be verified against a list of eligible values.

### Response reliability

Although the method is bias free when applied to actual consumer transactions, as other stated preference surveys it may be susceptible to strategic response bias and incentive compatibility bias when applied to hypothetical choice situations.

Strategic response bias typically occurs in SP surveys when respondents anticipate that their responses would influence the range of attribute values of the alternatives. In mode choice for example, if respondents are led to believe that their responses may influence the price or the speed range of the alternative, they might specify low prices and high speed thresholds at the criteria specification stage and choose low cost and high speed alternatives at the choice stage. Strategic response bias can be mitigated by decreasing the respondents' awareness regarding their ability to influence the supply of alternatives. Two design elements of the proposed method aim at mitigating strategic response bias: (i) the choice is made from a fixed product inventory, hence individuals are unaware that their responses can influence the range of attribute values, and (ii) the design of the experiment as a choice task masks the importance of choosing any attribute value over another as a main research purpose. The criteria specification stage is especially susceptible to strategic response bias due to respondents associating the order of the criteria with their relative importance. Accordingly, at this stage the selection of the criteria should be left entirely to the respondents' discretion.

Incentive compatibility bias occurs in SP surveys when respondents do not bear the consequences of their choices. Specifically, respondents might choose more expensive alternatives than they could afford when no actual payments are involved. In the marketing literature (Wang et al., 2007), incentive compatibility bias is mitigated by associating the hypothetical choice with an actual probability for making a paid transaction. Specifically, after making their choice, respondents are asked to purchase the alternative that they chose, depending on a lottery result. However, the association of the hypothetical choice with an actual transaction probability is limited to inexpensive tangible products, which is usually not the case in transport and urban planning. A design element of the proposed method that aims at mitigating incentive compatibility bias is the use of the price criterion to delimit the universal realm of alternatives. A high price threshold results in many alternatives, increasing the effort needed for the choice process. A low price threshold results in a small or null set of alternatives, decreasing satisfaction from the choice process (Iyengar and Lepper, 2000). Thus, respondents are encouraged to state their true price range in order to compromise between the price and the cognitive effort that is necessary in the choice process.

## EMPIRICAL APPLICATION: SURVEY DESIGN

The proposed elicitation method was applied to a stated preference experiment of off-campus rental apartment choice by students. The experiment was conducted by means of a

custom designed website, which was inspired by existing real-estate portals in order to evoke the feeling of a realistic choice situation. In the experiment, respondents searched a synthetic real-estate database according to a pre-specified list of criteria and threshold values. From the resulting set of alternatives, they chose their three most preferred apartments and ranked them by their order of preference. Respondents were allowed to conduct the database search multiple times by revising their selected thresholds. The final choice and the thresholds leading to it were automatically coded into the database. The next subsections describe the generation of the synthetic database, the criteria specification and the questionnaire design, present the website structure and discuss the issue of incentives.

## Synthetic database generation

The synthetic apartment database was generated on the basis of a statistical analysis of four popular on-line real-estate portals for students' rental apartment choice in Israel. The four websites are extremely popular since they allow both publishing and reading free advertisements without on-line registration. The retrieved data sample contained 310 distinct apartments for rent in Haifa, which were advertised on on-line real-estate databases during the winter semester of 2007. The retrieved apartment inventory was analyzed by studying the distribution of apartment attribute values, calculating the correlation among attributes, and estimating regression models to uncover relations among attributes.

The synthetic real-estate database included a fixed inventory of 600 apartments representing six neighbourhoods in the city of Haifa. Each apartment in the database was characterised by 18 attributes including neighbourhood, walking time to campus, noise level, price, size, number of rooms and balconies, renovation status, floor, number of roommates and smoking policy, availability of view, parking, security bars, elevator, air conditioning, solar water heating and washing machine. The synthetic real-estate dataset was generated with the intention to maintain behavioural realism while providing sufficient variability in the generated values. Hence, the composition of the synthetic read-estate dataset relied on random draw of apartment attribute values from distributions with parameters based on the statistical analysis of the retrieved data inventory.

Duplicate and dominant alternatives produced by the generation process were removed from the dataset to avoid their influence on the choice process resulting in spurious model estimates. Duplicate alternatives were defined as apartments that are not easily differentiable under the conditions of information load in terms of number of alternatives and attributes. Accordingly, alternatives were removed as duplicates when five out of six of the search criteria shared the same attribute values. Dominant alternatives were defined as apartments that were either high quality apartments with very low monthly rent or high quality apartments located in close proximity to the campus. Following the generation process and the removal of duplicate and dominant alternatives, the characteristics of the generated dataset were compared to the retrieved apartment inventory to confirm the desired similarity between the retrieved and the generated data sources.

## Search criteria

The search-criteria for eliminating alternatives were derived from a pilot survey among 74 students. The relevant criteria were apartment sharing, location, maximal rent price, number of rooms, proximity to campus (walking time in minutes), noise level and parking availability. Rent price values were expressed in U.S. dollars, the currency commonly used in Israel to indicate monthly rents. The rent price varied between $150 and $700 per month, with increments of $10, to reflect the actual price range observed on the market. Apartment sharing was defined as the possibility to select either a vacant apartment or an apartment with roommates. The location criterion included the six metropolitan core neighbourhoods. The number of rooms varied between 1 and 5. The walking time ranged between 5 and 30 minutes. The noise criterion included four levels differentiating between local street rear apartment, local street front apartment, main street rear apartment, and main street front apartment. Parking availability was binary.

## Questionnaire design

The questionnaire consisted of questions regarding personal information, perceived location amenities, price perceptions, travel preferences and study preferences. Personal related questions included socio-economic characteristics, transportation, residential characteristics and smoking habits. Perceived location amenities for each neighbourhood included job and leisure accessibility, public open space availability, campus accessibility by public transport, and perceived car travel time to campus. All the items were expressed on a seven-point Likert scale, except car travel time that was expressed in minutes. Information regarding attitudes perceptions and preferences was collected through indicators expressed on a seven-point Likert scale. The indicators were retrieved from the literature, since the development of valid and reliable scales was out of the scope of the current research. Price perceptions were based on Lichtenstein et al. (1993). Study preferences (on-campus versus home) were constructed similarly to attitudes towards telecommuting (Mokhtarian and Bagley, 2000). Travel preferences were adopted from Handy et al. (2006).

## Website design

A custom designed website was developed in order to collect the data from the proposed questionnaire and the two-stage choice experiment. The website was connected to a database that contained the synthetic apartment dataset and tables for automatic coding of the respondents' questionnaire answers, elicited threshold values and choice outcomes.

In order to control for sample reliability and facilitate the unique identification of the respondents, students were asked to insert their identification card number upon entering the website. This identification method allowed schedule flexibility in completing the survey and prevented problems resulting from unstable internet connectivity, since it allowed multiple entries to the website by the same respondent while controlling for duplicate answers. In order to tackle the problem of non-response due to privacy violation, students were also

given the possibility to complete the survey anonymously by typing a pre-specified identification number, provided that they waved their rights to the incentives.

In order to encourage respondents to provide reliable information, students were notified that a careful and truthful completion of the questionnaire was a necessary condition for receiving the incentive. Students were also advised about the existence of a procedure for the detection of inconsistent, careless and random answers. In addition, a variable recording the submission time for each task was collected automatically in order to control for random and careless answers. In particular, a very short completion time relatively to the entire sample's average completion time served as a proxy indicator for random or careless answers along with detection of random data patterns.

The survey was split into two parts that could be accessed separately in the website. The first part of the website consisted of the questionnaire regarding personal information followed by the two-stage choice experiment. The second part of the website consisted of the questionnaire regarding attitudes, perceptions and preferences. The division of the survey in parts was designed to decrease respondents' burden by creating a sense of satisfaction on task completion, by allowing partial completion of the survey, and by providing schedule flexibility in completing the entire survey. In addition, the first part of the survey was designed as self-sufficient so that responses from drop-outs could be included in the data analysis.

The website structure is illustrated in Figure 2. The first page of the first part (part A) presented a questionnaire regarding respondents' personal information. A data verification function verified full completion of the questions in the page. Upon successful submission of the questionnaire page, the respondents were directed to the two-stage choice experiment.

The structure of the two-stage experiment within the website consisted of the following elements:

1. A page asking the respondents to specify their tolerated criteria thresholds from a menu of criteria threshold values. Figure 3 presents the criteria specification page.

2. A query in structured query language (SQL) for retrieving the viable choice set from the database upon submission of the specified criteria thresholds.

3. A database containing the generated apartment dataset, from which a record-set containing the viable choice set was retrieved upon the execution of the SQL query.

4. A page presenting the retrieved record-set of viable alternatives and inviting respondents to choose their three most preferred alternatives.

The criteria specification page did not provide any information regarding possible dependence among criteria or their order of importance. The criteria were listed in a table format to prevent inferences regarding their relative importance and their selection was

entirely at the respondents' discretion. In addition, the selection of criteria thresholds did not indicate any linkage among them.

Data verification functions checked that the choice set size was manageable and that the same alternative was not ranked more than once. In the case that the SQL query yielded either an empty or an unmanageable (over 100 alternatives) choice set, the list of viable apartments was not presented and an alert message was set asking respondents to redefine their criteria thresholds. In the case of duplicate ranked alternatives, an alert message was sent and the choice outcomes were not coded into the database. Upon successful completion of the two-stage choice experiment, both the specified criteria thresholds and the corresponding choice outcomes were recorded into the database.

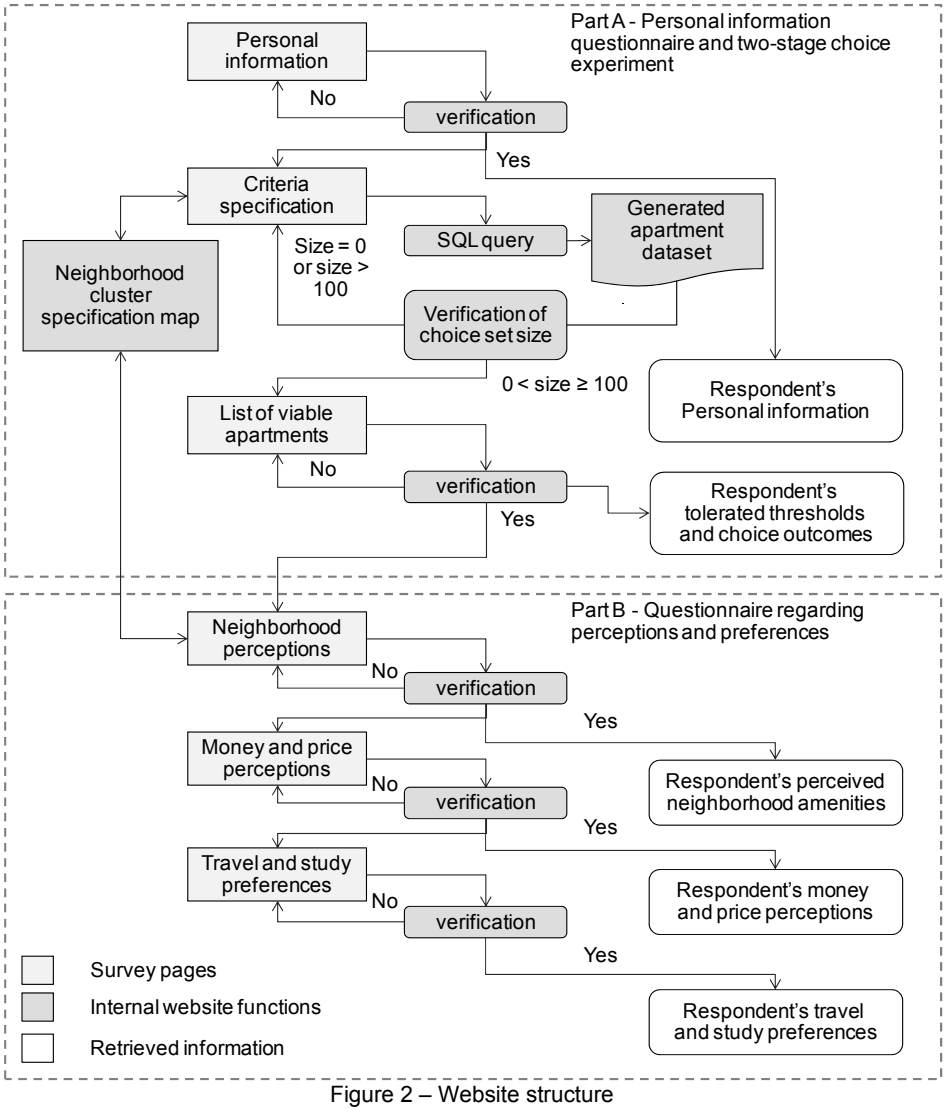


Figure 2 – Website structure

In the second part of the website (part B), a questionnaire regarding perceptions, attitudes and preferences was presented over multiple pages to facilitate its readability. Upon

automatic verification of full completion of the questions in every web page, responses were recorded into the database and respondents were directed to the next web page.

To facilitate communication with the respondents, instructions could be read and detailed maps could be viewed by opening pop-up windows at every stage of the survey. A 24-hour active phone number was provided on the first page of the website and an e-mail link was embedded on every web page in order to allow respondents to ask questions and to report interrupted sessions due to connectivity problems in real-time.

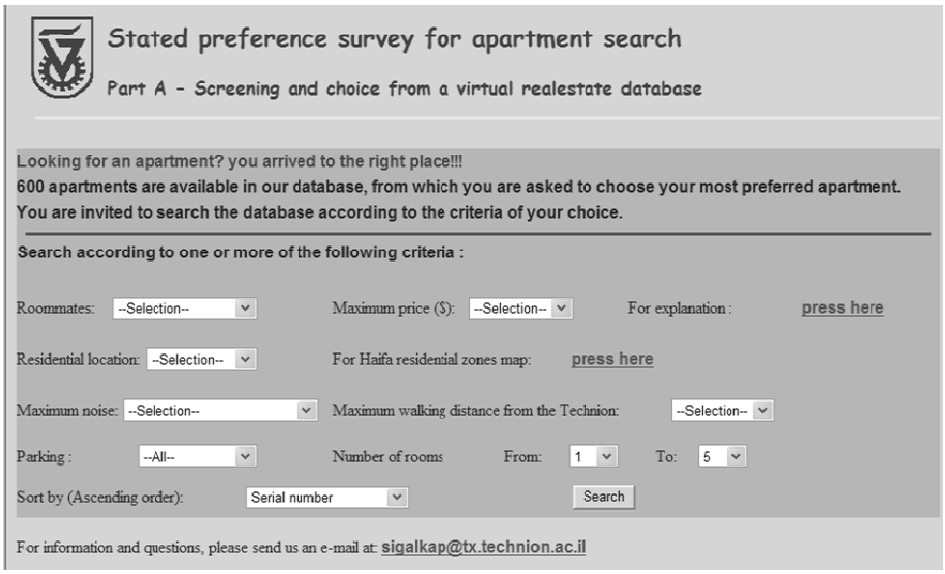


Figure 3 – Criteria specification web page

## Incentives and promotion

Participation in a monetary prize raffle was offered to students as an incentive for completing the survey. Three reasons guided the choice of a prize raffle over guaranteed individual incentives: (i) large prizes from raffles are more effective than guaranteed small individual payments in web based surveys (Bosnjak and Tuten, 2003); (ii) response quality, sample composition and survey outcomes of web-based surveys are not adversely affected by using a prize raffle as an incentive (Goritz, 2004); (iii) prize raffles allow offering substantial incentives within budget constraints without posing limitations on sample size.

Monetary rewards were preferred over gift certificates since money is independent from taste preferences. A total budget of 1,000 U.S. Dollars was allocated for the raffle, and 23 prizes were defined within the $25-$250 range, in accordance with ranges associated to web-based surveys in other countries. The highest prize reflected the average monthly rent for a student in a shared apartment. The prize structure was designed in accordance with rank-dependent expected utility theory (Quiggin, 1991) in order to attract both risk seekers and risk averters.

The survey was conducted during the spring semester of 2007 over a period of forty days. An official e-mail message was sent to all students. In addition, postcard-size leaflets were distributed on campus in the beginning, middle and end of the survey for a total of 3,000 postcards. Advertising the survey by postcards allowed the inclusion of all the necessary information in a small portable format that transmits a positive image as postcards are a popular advertising tool addressing young audience for entertainment activities.

# EMPIRICAL APPLICATION: RESULTS

## Data collection efficiency

The efficiency of the proposed data collection methodology is evaluated from the researchers' and the respondents' perspectives. The efficiency from the researchers' perspective concerns obtaining high-quality data at low costs. The efficiency from the respondents' perspective concerns having minimal disturbance to daily activities.

### *Efficiency from the researchers' perspective*

The efficiency of the web-based data collection from the researchers' perspective is assessed by survey completion rate, drop-out rate, share of valid responses and cost-benefit per respondent. The cost-benefit per respondent and the level of correspondence between the completion rates and the advertising efforts indicate the effectiveness of data collection. The share of valid records denotes the quality of the data.

The survey completion rate reflects the efforts in advertising the survey. The highest share of completed surveys (26.2%) was obtained following the official e-mail. Each of the three occasions of distributing leaflets produced an immediate increase of 10% with respect to the total completion rate.

From 1,325 distinct respondents who started the survey, 84.1% completed the survey without dropping out. The database yielded records of 1,049 valid respondents. Valid respondents were defined as respondents with complete and non-duplicate records, with a valid student number, and without random answers. The high share of valid answers (93.6% of the respondents who completed the survey) indicates the quality of the data.

The costs of the survey totalled roughly 3,000 U.S. Dollars (2007 exchange rate) including website construction, incentives and promotion. The database yielded 1,049 valid records of respondents resulting in a cost-benefit ratio of 2.86 U.S. Dollars per respondent. This cost-benefit ratio is extremely effective both in comparison with other surveys conducted in Israeli universities and with respect to the prospect of calculated incentive per respondent.

*Efficiency from the respondents' perspective*

The efficiency of the web-based environment from the respondents' perspective is assessed by looking at the hourly distribution of the completed surveys as an indicator of the usefulness of schedule flexibility. As demonstrated in Figure 4, the survey completion times were spread around the clock, which indicates the usefulness and the importance of time flexibility for the respondents.

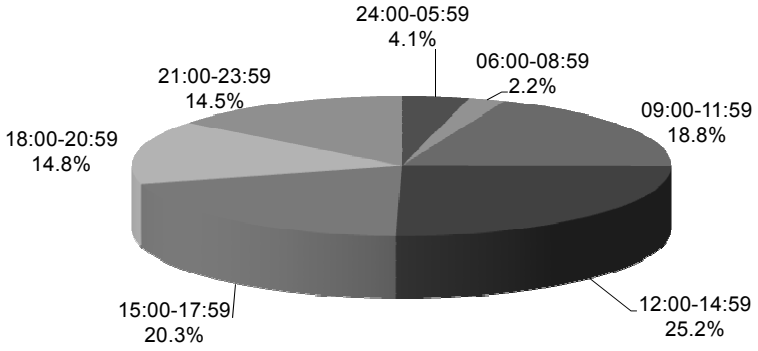


Figure 4 – Survey completion by daily period

## Sample demographics

Socio-economic characteristics of the survey participants are summarized in Table 1. The demographics of the Technion student population are not public records, but some information was retrieved from the Israeli Central Bureau of Statistics (CBS) and other sources in order to evaluate whether the sample is representative of the student population. The percentage of female participants is fairly close to the 35.3% female student population in the Technion (CBS, 2006). The median age of 26.6 years among the survey participants corresponds to the median age of 26.1 years of the general student population (CBS, 2005a). The share of participants living in dormitories matches the share of student population in dormitories assuming full occupancy (Technion, 2007). Among the 55.1% of survey participants currently living in their own apartments, 32.5% rent an apartment alone or with roommates, 14.0% live with a partner and 53.5% are married. These shares fairly agree with CBS records (CBS, 2005b), which report that 32.8% of the students not residing with their parents rent an apartment, 9.4% live with a partner and 57.8% are married. The distribution of the place of residence is compatible to the geographic location of the Technion. The share of employed undergraduates is 43.3%, which is slightly lower than the employment rate of 52.0% among engineering students (Intel press room, 2007).

Table 1 – Sample Demographics

| Variable | Categories (%) | | | | |
|---|---|---|---|---|---|
| Gender | Male<br>60.1 | Female<br>39.9 | | | |
| Marital Status | Married<br>29.5 | Single<br>70.5 | | | |
| Age | ≤ 21<br>8.2 | 22-24<br>21.0 | 25-29<br>50.9 | 30-34<br>16.9 | 35-44<br>3.0 |
| Income source | Scholarship<br>45.4 | Full-time<br>11.2 | Part-time<br>25.1 | None<br>18.3 | |
| Residential arrangement | Dorms<br>32.3 | Rent alone<br>5.7 | Rent with roommates<br>12.2 | Co-habit with spouse<br>37.2 | Parent's house<br>12.6 |
| Place of Residence | Haifa<br>65.0 | North Israel<br>23.3 | Center Israel<br>7.8 | Other<br>3.8 | |
| Car availability | Every day<br>45.9 | 2-3 times weekly<br>9.9 | Once a week<br>10.6 | 2-3 times monthly<br>7.8 | Rarely<br>25.8 |

## Threshold elicitation stage

### *The importance of elimination-based choice set formation*

At the threshold elicitation stage, eight search criteria were available to respondents for extracting their viable choice set from the apartment dataset: apartment sharing, neighbourhood, maximum monthly rent price, maximum and minimum number of rooms, noise level, reserved parking availability and proximity to campus. The average number of selected criteria by respondents was 4.8 (SD=1.2). The distribution of the number of selected criteria by respondents is presented in Figure 5.

The share of respondents who selected each criterion is presented in Table 2. The most frequently selected criteria for delimiting the universal realm of apartments to a viable choice set were apartment sharing, neighbourhood cluster and maximum monthly rent price. The most popular combination of thresholds selected by 17.1% of the respondents included all the criteria except for parking. The second most popular combination selected by 8.0% of the respondents included apartment sharing, neighbourhood, maximum monthly rent price, proximity to campus and noise level.

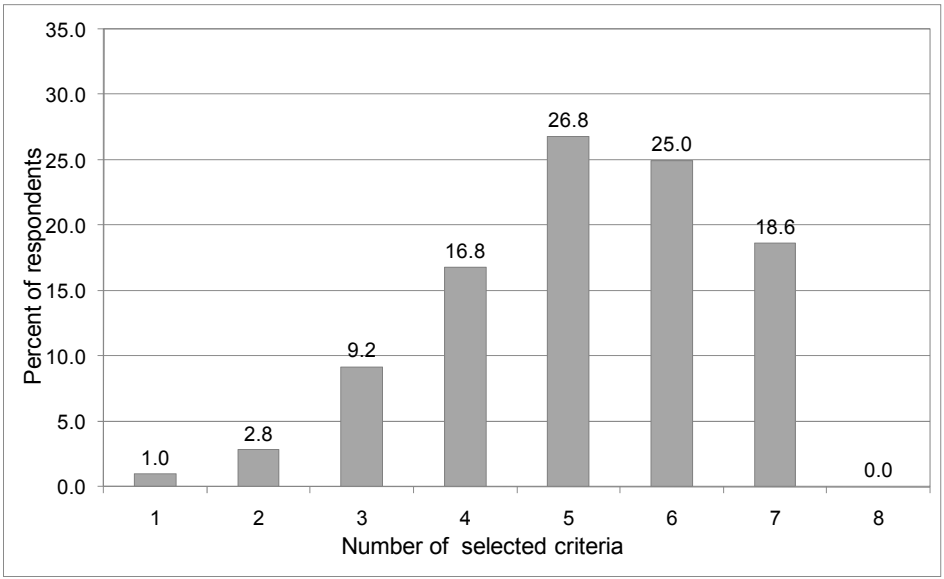


Figure 5 – The distribution of the number of selected criteria across respondents

Table 2 – The distribution of criteria selection across respondents

| Criterion | Respondents who selected the criterion (%) |
|---|---|
| Apartment sharing | 94.5 |
| Maximal rent price | 88.8 |
| Neighbourhood | 87.2 |
| Maximal walking time to campus | 67.5 |
| Maximal number of rooms | 59.5 |
| Maximal noise level | 58.1 |
| Minimal number of rooms | 53.7 |
| Availability of reserved parking | 8.6 |

### *Threshold distribution across the population*

55.2% of the respondents retained only vacant apartments in their choice set, while 39.3% preferred to retain only shared apartments and 5.5% did not delimit their choice set according to the apartment sharing criterion.

The distribution of the selected monthly rent thresholds is presented in Figure 6. Excluding respondents who did not delimit the universal realm by selecting a monthly rent threshold, the mean of this distribution is $381.3 (SD=$134.5), which is only 14.5% higher than the mean rent price in the generated apartment dataset. Even though the price threshold was listed in $10 increments, most respondents (78.5%) selected the monthly rent thresholds in multiples of $50 (i.e., $200, $250,…,$700), which reflects the sensitivity of respondents to changes in rent prices.

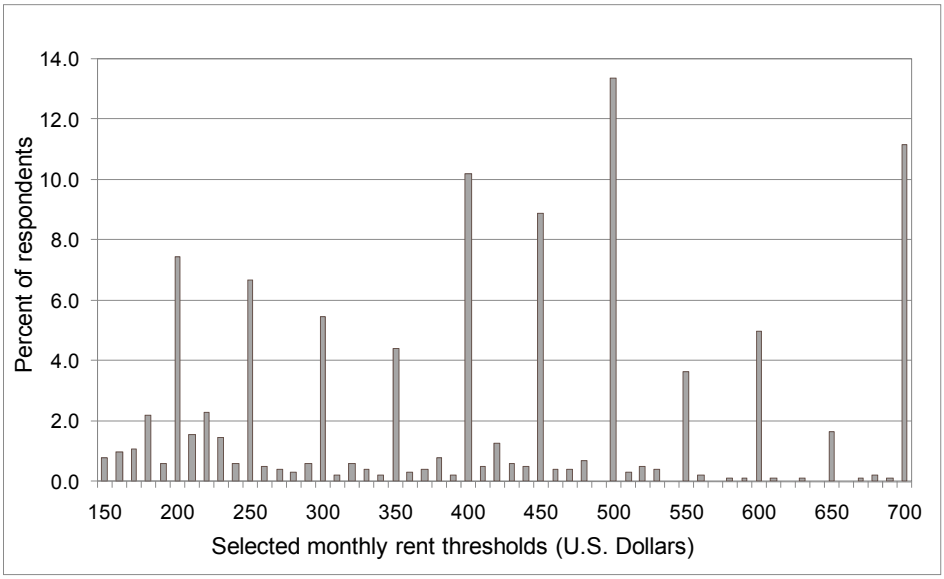


Figure 6 - Distribution of selected price threshold values

The six neighbourhoods represent four neighbourhood types that are relevant to students' residential choice. The first type (type I) is adjacent to the campus but offers little employment or leisure opportunities. The second type (type II) is located in close proximity to campus, although slightly further away than type I. The third type (type III) is located farther from campus in the new city centre. It is not easily accessible by public transport, but offers abundance of shopping, leisure and employment opportunities. The fourth type (type IV) is located farther from campus in the old city centre. It offers very good accessibility to campus by public transport and abundance of low-price shopping opportunities, although it offers little employment or leisure opportunities. Figure 7 describes the distribution of neighbourhood type selection across respondents. Type I neighbourhood is by far the most attractive to students, while neighbourhood type IV is by far the least attractive to students.

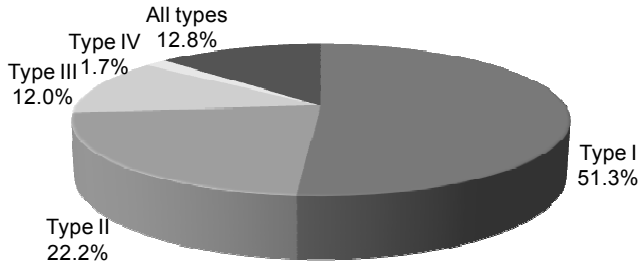


Figure 7 - Selected neighbourhood types across respondents

The option to delimit the realm of apartments by walking time to campus was available to respondents who delimited the universal realm to a neighbourhood in close proximity to campus (Type I and Type II neighbourhoods). Figure 8 displays the distribution of the maximum walking time across respondents. Respondents were tolerant with respect to walking time to the campus. Interestingly, only 12.3% were willing to walk up to 10 minutes to campus, while 44.1% of the respondents were willing to walk at least 20 minutes.

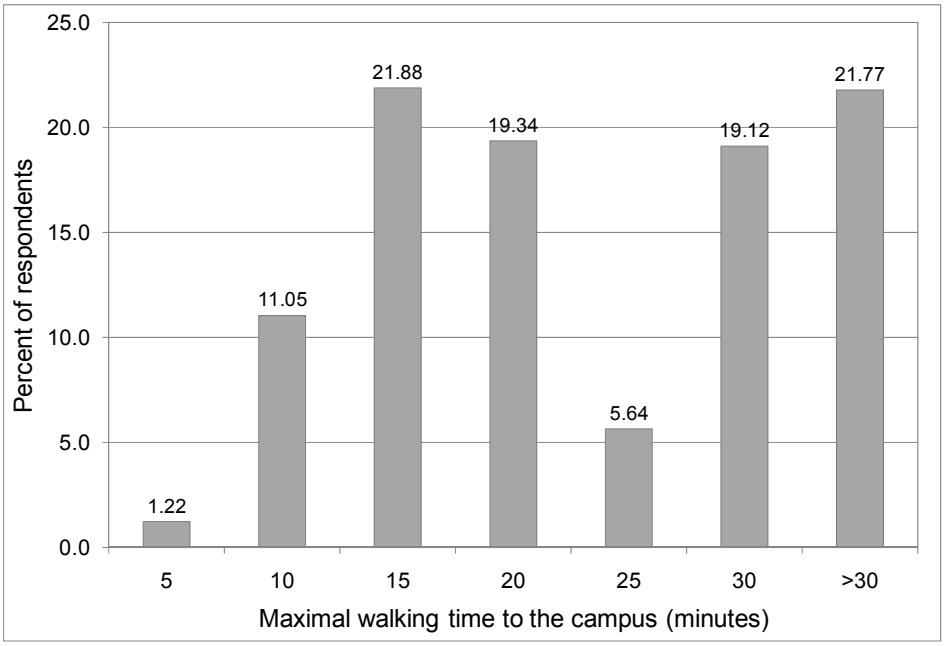


Figure 8 - Selected maximum walking time to campus across respondents

Table 3 details the two-way distribution of the range of number of rooms that was selected by respondents. Most frequently, respondents delimited their realm of alternatives to apartment size ranging from 2.0 to 4.5 rooms.

Table 3 – Minimum by maximum number-of-rooms criteria

| min/max | 1.0-1.5 | 2.0-2.5 | 3.0-3.5 | 4.0-4.5 | > 4.5 |
|---|---|---|---|---|---|
| 1.0-1.5 (%) | 0.2 | 2.9 | 5.2 | 4.1 | 28.3 |
| 2.0-2.5 (%) | - | 1.1 | 11.1 | 17.4 | 5.3 |
| 3.0-3.5 (%) | - | - | 0.8 | 10.7 | 8.0 |
| 4.0-4.5 (%) | - | - | - | 0.3 | 4.7 |
| > 4.5 (%) | - | - | - | - | 0.00 |

Figure 9 displays the distribution of respondents according to their tolerated maximal noise level. The noise criterion was important to a large share of the respondents, as 38.4% of the respondents delimited their universal realm to apartments situated at local streets.

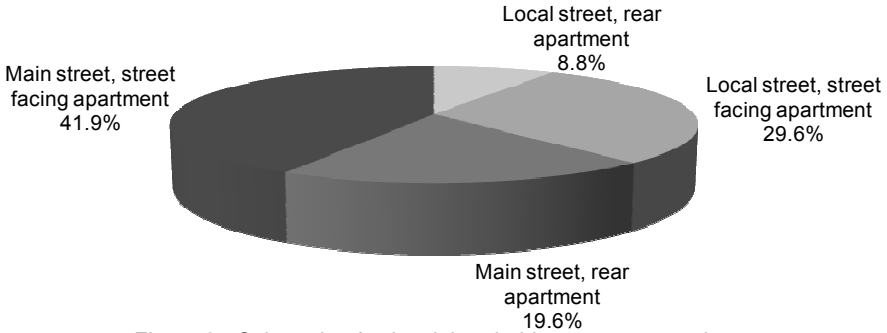


Figure 9 - Selected noise level thresholds across respondents

### *Linkage between threshold selection and individual characteristics*

As the data collection method assumes partial information regarding the universal realm of alternatives at the criteria specification stage, the criteria specification can be related only to individual characteristics. Table 4 presents the results of an ordered-response probit model for the monthly rent price threshold as an example of the linkage between threshold selection and individual characteristics. The model is estimated for the full sample of 1049 participants and accounts for variables that are significant at the 0.05 significance level in the model based on individual characteristics.

Table 4 – Ordered-response probit estimation results for the monthly rent price threshold

| Variable | Category | Price threshold model | |
|---|---|---|---|
| | | Coefficient | P-value |
| Marital status | Married = 1, Single = 0 | 0.540 | 0.000 |
| Gender | Male = 1, Female = 0 | -0.232 | 0.001 |
| Age | Continuous (in years) | 0.052 | 0.000 |
| Monthly Expenses | < $500 [a] | - | - |
| | $500-$1,000 | 0.308 | 0.001 |
| | $1,000-$1,500 | 0.441 | 0.000 |
| | >$1,500 | 0.612 | 0.000 |
| Employment status | Unemployed/ Scholarship [a] | - | - |
| | Part time job | 0.155 | 0.058 |
| | Full time job | 0.435 | 0.000 |
| Car availability | Rarely [a] | | |
| | Weekly | 0.222 | 0.044 |
| | Daily | 0.320 | 0.000 |
| Current place of residence | Middle income neighborhoods in Haifa [a] | - | - |
| | High income neighborhood in Haifa | 0.372 | 0.000 |
| | Tel Aviv | 0.303 | 0.029 |
| Price Knowledge | Continuous | 0.068 | 0.002 |
| Threshold values | 250 | 0.878 | 0.004 |
| | 300 | 1.297 | 0.000 |
| | 350 | 1.559 | 0.000 |
| | 400 | 1.753 | 0.000 |
| | 450 | 2.176 | 0.000 |
| | 500 | 2.526 | 0.000 |
| | 550 | 3.064 | 0.000 |
| | 600 | 3.245 | 0.000 |
| | 650 | 3.500 | 0.000 |
| | 700 | 3.598 | 0.000 |
| Number of observations | | 1,049 | |
| Log-Likelihood at estimates | | -2164.4 | |
| McKelvey-Zavoina Pseudo-$R^2$ | | 0.35 | |

[a] – base category

*Correlation patterns across criteria*

Apartment sharing is moderately correlated with price (Spearman's Rho = 0.57) and walking distance (Spearman's Rho = 0.43), namely respondents who delimited the universal realm to shared apartment stated lower price thresholds and lower walking time thresholds than respondents who delimited the universal realm to vacant apartments. Hence, respondents were willing to share an apartment in order to save money or to live in greater proximity to campus. The price criterion is loosely correlated with the minimal tolerated number of rooms (Spearman's Rho = 0.32) and is moderately correlated with neighborhood type III (Spearman's Rho = 0.44) indicating that respondents stated higher price threshold values for larger apartments and for apartments located in the new city center. All the correlations are significant at the 0.05 significance level.

## Choice stage

The selected combination of tolerated criteria thresholds yielded the viable choice set for each respondent. The distribution of the viable choice set size is displayed in figure 10. The average choice set size is 17.0 alternatives (SD=17.5) and the median choice set size is 11.0 alternatives. 48.3% of the respondents had up to 10 alternatives in their viable choice set and 86.2% of the respondents had up to 30 alternatives.

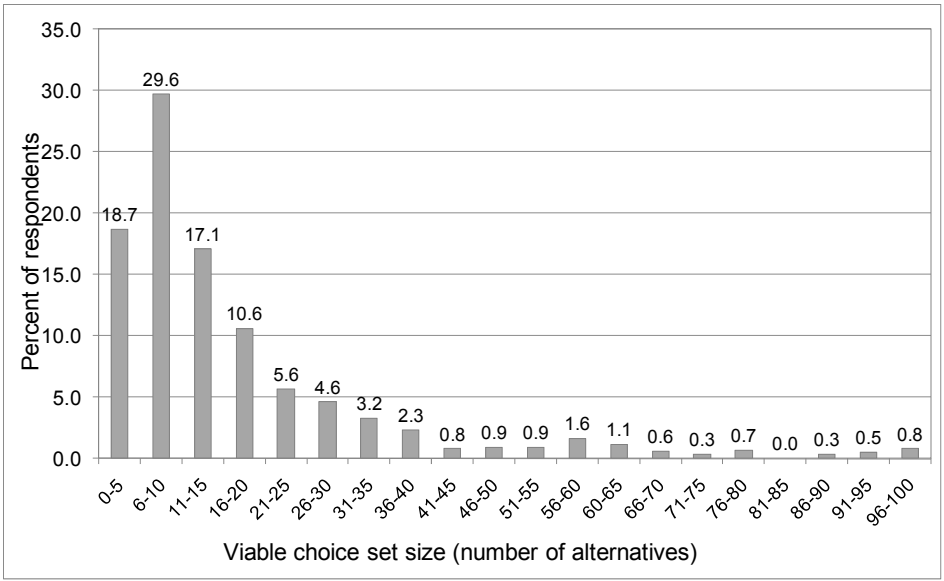


Figure 10 - Size of the viable choice set across respondents

Respondents were given the option to sort their viable choice set according to one criterion of their liking. 72.3% chose to sort the viable choice set. 66.6% of these respondents sorted by price, which along with the frequency of elimination by price (88.8%) establishes it as the most important criterion for choice set formation. The second and third most preferred criteria for sorting the viable choice set were neighbourhood and proximity to campus that were selected by 12.9% and 9.2% of the respondents, respectively. The relative position of the chosen apartments on the list of viable ones as seen by the respondents was also influent:

60.3% of the respondents chose their first priority choice, 55.7% chose their second best choice and 50.9% chose their third best choice among their top five listed apartments.

## Correlation across stages

Several variables, such as monthly rent price, have a dual role both as thresholds at the threshold elicitation stage and as attributes at the choice stage. For the price variable, the relationship between the selected threshold and the corresponding choice outcome was investigated. Considering all three ranked choices per respondent, the monthly rent price of the chosen alternative is strongly correlated with the price threshold value (Pearson's R=0.72) and its distribution in terms of percentage difference with respect to the price threshold is presented in figure 11. For almost a third of the respondents (30.2%), the difference between the monthly rent price of the chosen apartment and the monthly rent price threshold was at most 15%, and for 51.1% the difference was at most 25%. These results establish the linkage between the consecutive choices in the two-stages.

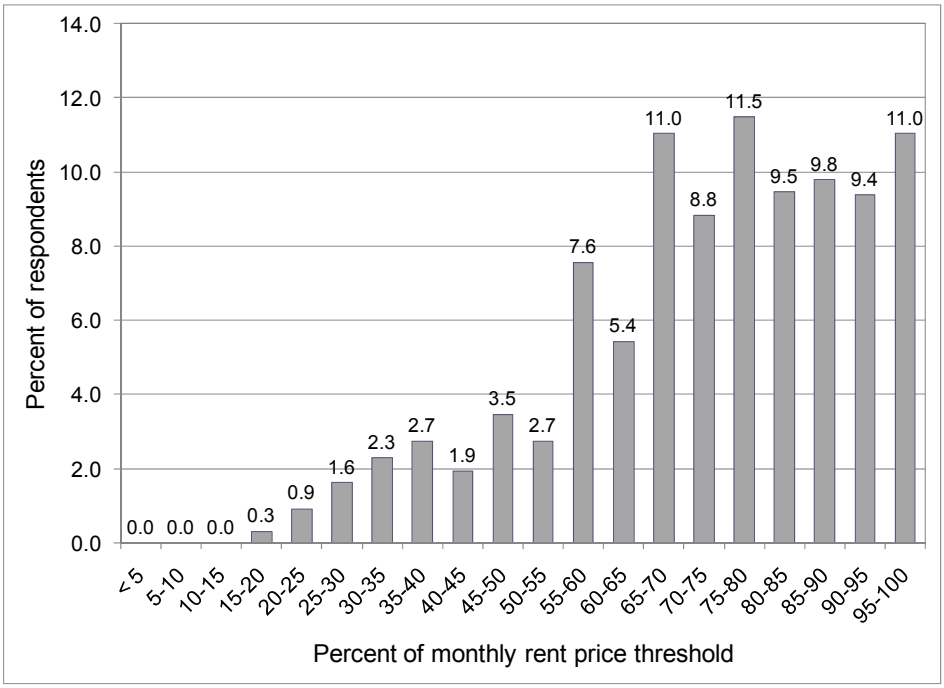


Figure 11 - Monthly rent price across choice outcomes as a function of the price threshold value

The monthly rent price range of the viable choice set was defined by the rent price threshold conditional on apartment availability. Since threshold selection was conducted in conditions of partial knowledge, that is the respondents were not aware of the "true" price range in the generated database, the actual range in the choice set could be narrower than the respondent's tolerated price range. For 72.0% of the respondents the difference between the tolerated price threshold and the highest price within the viable choice set was at most 10%. The monthly rent price of the chosen apartments was strongly correlated with the minimum (Pearson's R = 0.78), maximum (Pearson's R = 0.85) and average price (Pearson's R =

0.90) of the apartments included in the choice set. Figure 12 presents the price of the chosen alternative in terms of percentage of the average price of the viable apartments.

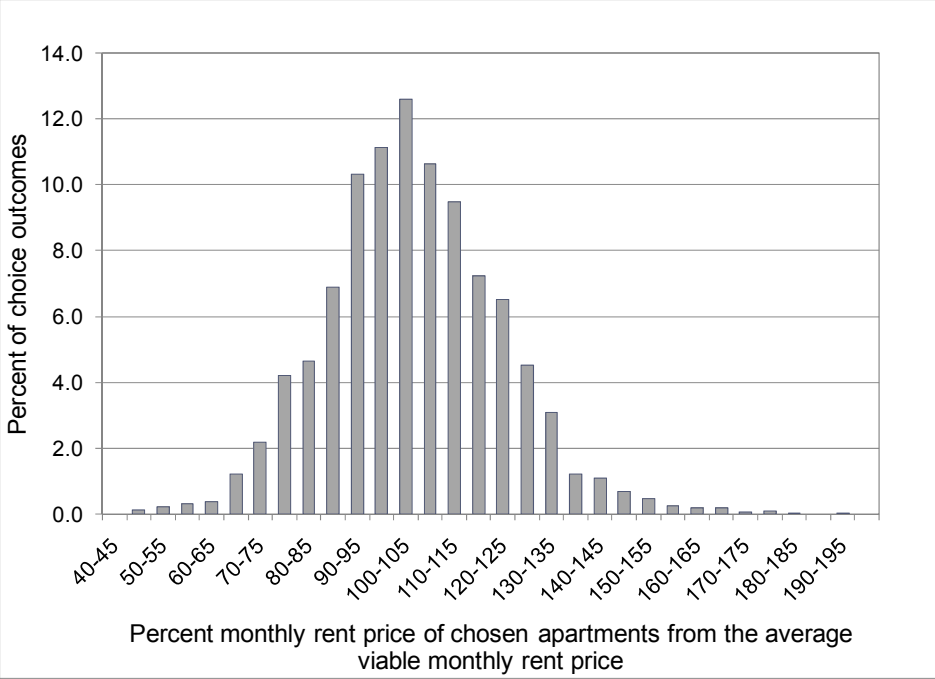


Figure 12 - Monthly rent price across choice outcomes as a function of the average price of the viable apartments

## CONCLUSIONS

The current study proposes a novel data collection method for the simultaneous elicitation of criteria thresholds, which serve to delimit the universal realm of alternatives to a viable choice set, and respective choice outcomes. Data were collected in a digital economy environment by means of a custom designed website, which seamlessly recorded the two-stage choice process. The procedure is applied to rental apartment choice of students as an example of a non-repetitive choice situation entailing multiple criteria and many alternatives.

As the current study breaks new ground in unravelling semi-compensatory choice, three important aspects of the choice set formation process are observed for the first time. First, elimination-based choice set formation is crucial in complex choice situations, as 85.6% of the respondents selected at least four criteria thresholds for delimiting the universal realm to a viable choice set. Second, elimination-based choice set formation is insufficient as a sole simplification strategy, since 72.3% of the respondents voluntarily chose to sort the alternatives in the viable choice set according to the criteria of their liking. The importance of sorting as an additional simplification heuristic is indicated by the fact that 60.3% of the respondents chose their first priority choice among their top five listed apartments. Third, the size of a manageable choice set is less than a dozen alternatives, as the median choice set size among survey respondents was 11.0 alternatives and 48.3% of the respondents had up to 10 alternatives in their viable choice set. 86.2% of the respondents had up to 30

alternatives, which is expected since choice sets of larger size become unmanageable (Iyengar and Lepper, 2000).

Results demonstrate the ability of the proposed data collection procedure to observe the distribution of thresholds across the population, to identify correlations among criteria thresholds and to understand the linkage between threshold selection and individual characteristics. The results of the current study show that thresholds are correlated, and that the correlations are related solely to intrinsic perceptions of respondents since the respondents could not infer such information from the survey. In addition, results show the existence of population heterogeneity in threshold selection and that a significant proportion of the variance (35%) can be explained by individual characteristics.

When applied to hypothetical choice situations, the method may be susceptible to strategic response bias and incentive compatibility bias usually associated with direct elicitation methods. Instead, when applied to actual on-line consumer transactions performed in a digital economy environment, the proposed method is bias free. In the current hypothetical experiment, the difference between the mean of selected price threshold values and the mean rent price in the synthetic database, which is based on actual market prices, is 14.5%. Considering that, due to the complexity of the experiment, respondents could not easily infer the price distribution in the synthetic database from repetitive search trials, this difference reasonably indicates that the threshold values are unbiased. Probably, the design of the experiment is efficient in mitigating possible biases. This point remains to be investigated and assessed in further research.

Choice set formation and choice from the viable options are assumed to be distinct mental processes (Bovy, 2009) distinct cognitive processes and hence are treated as independent in the literature of semi-compensatory models based on Manski's (1977) formulation. However, the threshold elicitation stage and the choice stage are not independent in that the final choice is dependent on the set of alternatives passed on from the threshold elicitation stage. Additional dependence derives from the employment of the two cognitive processes by the same individual. The current study confirms that dependence between the two-stages by observing the price variable, which has a dual role both as a threshold at the choice set formation stage and as an attribute at the choice stage. Results show strong correlation between the two-stages, as the price of the chosen product variation is strongly correlated with the price threshold as well as with the price range limits in the available choice set. These findings suggest the existence of anchoring and adjustment procedure at the choice stage. That is, after a-priori stating their thresholds, respondents update their preference structure by using either the thresholds or the average attribute values of the viable alternatives as external reference points. This result is of major importance since it calls for reconsideration of the currently prevailing assumption in semi-compensatory models that the error terms of the choice set formation and choice are independent.

Further development includes the application of the proposed procedure to other spatial and transportation related choices (e.g., car rental, travel fares, and recreational destination choice). The successful data collection of stated preferences demonstrates the potential of

the procedure for collecting revealed preferences from actual on-line transactions conducted via commercial websites. In the transport sector websites are readily available from airlines and train companies, from tourist agencies and car rental agencies.

Subsequently, the proposed data collection procedure can contribute to a better realisation of both the explanatory and predictive potential of semi-compensatory models and increase their ability to realistically represent behavioural decision processes. By relying solely on choice outcomes, current models have a limited ability to represent the non-compensatory choice set formation process. Frequent assumptions embedded in semi-compensatory models are independence of the thresholds from individual characteristics (Morikawa, 1995; Swait, 2001; Cantillo and Ortúzar, 2005; Cantillo et al., 2006; Castro et al., 2009), normal distribution of threshold values across the population (Swait, 2001; Cantillo and Ortúzar, 2005; Cantillo et al., 2006) and independence across thresholds of different criteria (Ben-Akiva and Boccara, 1995; Swait, 2001; Başar and Bhat, 2004; Cantillo and Ortúzar, 2005; Cantillo et al., 2006; Castro et al., 2009). The added information regarding threshold selection can contribute to the refinement of the mathematical representation of thresholds in semi-compensatory models. In addition, since currently analysts have to consider all the theoretically possible choice sets, semi-compensatory models are applicable to choice problems with a limited number of choice sets. In fact, all the aforementioned semi-compensatory models are applied to choice situations with up to nine choice sets. The collected data regarding individual choice sets alleviates the computational complexity embedded in semi-compensatory models, as it enables the analyst to consider the actually chosen choice sets for estimation purposes, rather than to consider the entire realm of theoretically possible choice sets. Last, the current study shows that a correlation exists between the choice set formation stage and the utility maximization stage. A potential development of semi-compensatory models may include the representation of the correlation between the two stages.

## REFERENCES

Başar, G. and C. R. Bhat (2004). A parameterized consideration set model for airport choice: application to the San Francisco Bay area. Transp Res Part B, 38, 889-904.

Ben-Akiva, M. E. and B. Boccara (1995). Discrete choice models with latent choice sets. Int J Res Market, 12, 9-24.

Bosnjak, M. and T. L. Tuten (2003). Prepaid and promised incentives in web surveys: an experiment. Soc Sci Comput Rev, 21, 208-217.

Breidert, C., M. Hahsler and T. Reutterer (2006). A review of methods for measuring willingness-to-pay. Innov Market, 4, 8-32.

Cantillo, V., B. Heydecker and J. d. D. Ortúzar (2006). A discrete choice model incorporating thresholds for perception in attribute values. Transp Res Part B, 40, 807–825.

Cantillo, V. and J. d. D. Ortúzar (2005). A semi-compensatory choice model with explicit attribute-thresholds of perception. Transp Res Part B, 39, 641-657.

Castro, M., F. Martinez and M. Munizaga (2009). Calibration of a logit discrete choice model with elimination of alternatives. Proceedings of the International Choice Modelling Conference, March 30-April 1, Harrogate, U.K.

Central Bureau of Statistics (2005a). Demographic characteristics of university candidates, stu-dents and graduates - table 22: student population by degree, age and field of studies.http://www.cbs.gov.il/www/publications/educ_demog_05/educ_demog_h.htm.

Central Bureau of Statistics (2005b). Living arrangements of young adults in 2000 by demographic and socio-economic characteristics - Working Paper No. 17 of the Demography Sector. http://www.cbs.gov.il/www/publications/pwmegurim17.pdf.

Central Bureau of Statistics (2006). Students in universities and other higher-education institutes - table 5: percent of women in the student population by degree, field of study and institution. http://www.cbs.gov.il/www/publications/stud_04/stud_h.htm.

Gensch, D. H. and J. A. Svestka (1979). An exact hierarchical algorithm for determining aggregate statistics from individual choice data. Manag Sci, 25, 939-952.

Göritz, A. S. (2004). The impact of material incentives on response quantity, response quality, sample composition, survey outcome, and cost in online access panels. Int J Mark Res, 46, 327-345.

Handy, S., X. Cao and P. L. Mokhtarian (2006). Self-selection in the relationship between the built environment and walking. J Am Plan Assoc, 72, 55-74.

Iyengar, S. S. and M. R. Lepper (2000). When Choice is Demotivating: Can One Desire Too Much of a Good Thing? J Pers Soc Psychol, 79, 995-1006.

Intel press room (2007). Employment status among university students. http://www.intel.com/cd/corporate/pressroom/emea/heb/archive/2007/341609.htm

Jedidi, K. and J. Z. Zhang (2002). Augmenting conjoint analysis to estimate consumer reservation price. Man Sci, 48, 1350-68.

Kohli, R. and V. Mahajan (1991). A reservation-price model for optimal pricing of multi-attribute products in conjoint analysis. J Market Res, 28, 347-54.

Lichtenstein, D. R., P. H. Bloch and W. C. Black (1988). Correlates of price acceptability. J Consum Res, 15, 243-52.

Lichtenstein, D. R., N. M. Ridgway and R. G. Netemeyer (1993). Price perceptions and consumer shopping behavior: a field study. J Market Res, 30, 234-245.

Manski, C. F. (1977). The structure of random utility models. Theor Decis, 8, 229–254.

McKelvey, R. D. and W. Zavoina (1975). A Statistical Model for the Analysis of Ordinal Level Dependent Variables. J Math Sociol, 4, 103-120.

Mokhtarian, P. L. and M. N. Bagley (2000). Modeling employees' perceptions and proportional preferences of work locations: the regular workplace and telecommuting alternatives. Transp Res Part A, 34, 223-242.

Monroe, K. B. (1971). Measuring price thresholds by psychophysics and latitudes of acceptance. J Market Res, 8, 460-464.

Morikawa, T. (1995). A hybrid probabilistic choice set model with compensatory and non-compensatory choice rules. Proceedings of the 7th WCTR, Sydney, Australia.

Payne, J. W. (1976). Task complexity and contingent processing in decision making: an information search and protocol analysis. Organ Behav Hum Perform, 16, 366-387.

Payne, J. W., J. R. Bettman and E. J. Johnson (1993). The adaptive decision maker. Cambridge University Press, Cambridge, MA.

Quiggin, J. C. (1991). On the optimal design of lotteries. Economica, 58, 1-16.

Shocker, A. D, M. E. Ben-Akiva, B. Boccara and P. Nedungadi (1991). Consideration set influences on consumer decision-making and choice: issues, models and suggestions. Mark Lett, 2-3, 187-197.

Swait, J. and M. E. Ben-Akiva (1987). Incorporating random constraints in discrete choice models of choice set generation. Transp Res Part B, 21, 91-102.

Swait, J. (2001). Non-compensatory choice model incorporating attribute cut-offs. Transp Res Part B, 35, 903-928.

Technion (2007). Facts about the Technion campus. http://www1.technion.ac.il/about

Tversky, A. (1972). Elimination by aspects: a theory of choice. Psychol Rev, 79, 281-299.

Wang, T., R. Venkatesh and R. Chatterjee (2007). Reservation price as a range: an incentive compatible measurement approach. J Market Res, 44, 200-13.

Zheng, J. and J. Y. Guo (2008). A destination choice model incorporating choice set formation. Proceedings of the 87th TRB Annual Meeting, Washington, D.C., USA.